INVESTIGATION GUIDELINES

Appendix 11
October 1, 1991

HEAT TAPES

I. INTRODUCTION

A. Background Information

Heating tapes and cables, commonly called heat tapes, are specialized electrical heaters that are used primarily to prevent freezing of water pipes, drain pipes, gutters and down spouts. There are different heat tape designs for different applications (e.g., the design of heat tapes intended to protect water pipes differs from that of heat tapes intended for gutters.) Customarily, they are plugged into 120-V conventional receptacle outlets. Some manufacturers recommend that they not be used with extension cords. Other manufacturers specify that, if an extension cord is necessary, it must be properly sized, grounded, and certified for outdoor use.

Fires associated with heat tapes occur especially during the winter when the tapes are actively heating protected devices (i.e., pipes and gutters). We are seeking information that identifies the underlying causes of these fires so that appropriate corrective-action options can be selected.

Beginning in the fall of 1990, a high proportion of heat tapes and cables sold in the U. S. have been "listed" -- certified to recognized voluntary safety standards by Underwriters Laboratories (UL), Canadian Standards Association (CSA), or Factory Mutual (FM). There are differences among these standards, but we do not yet have indications that any one of these standards is superior to the others. Formerly, unlisted tapes were commonly available and used. If a heat tape ignition has occurred, it is important to determine if the tape was listed or not. Listed tapes bear a label that identifies the laboratory that performed the qualification tests.

B. Product Description

Heat cables and tapes are available in a wide variety of lengths and configurations. Typical shapes vary from round or oval cables to relatively flat wide tapes. Listed tapes have a braided metal shield covering the whole cable or tape; some metal shields are exposed, others are covered by a jacket of electrical insulation. It is important to determine if the heat tape associated with a fire was shielded or not. Not all shielded heat tapes Are listed.

As used in typical residential applications, pipe heat tapes are wound around a pipe or fastened along its length and then covered with some form of insulation(s) to limit the heat loss from the pipe. Usually moisture resistant tape is then wound over the glass-fiber strip. In determining possible causes of ignition, it is important to know the kind of material, if any, used to insulate the pipe and the heat tape. The instructions provided by the heat tape manufacturers specify the material, such as glass fiber, the thickness, and the kind of over wrapping tape to be used to protect the insulating strip from water and moisture.

There is no universal "correct" way of installing a heat tape. The criterion for any particular tape is the manufacturer's instruction. When the circumstances permit, photographs that illustrate the installation technique can be helpful in determining the cause of ignition. Differences in appropriate installation practices are particularly noted in the contrast between "resistance" type tapes and "self-regulating" tapes.

1. Resistance vs Self-Regulating

Resistance heat tapes (See Attachment, Figure l) incorporate thin wires of electrical resistance metals (similar to those in an electric blanket) and generate almost the same amount of heat power regardless of temperature of the tape. Many resistance heat tapes are equipped with thermostat switches that turn off the power to the heat tape at a temperature at which heat is no longer required to protect the pipe or gutter. Some thermostats are intended to be fastened in close contact with the pipe and covered with thermal insulation; others, to be mounted exposed to air, as determined by the manufacturer and stated in the instructions.

Self-regulating heat tapes (See Attachment, Figure 2) incorporate two copper wires that extend for the full length of the tape. When the tape is plugged into a 120-V a-c supply, the two wires have this voltage applied and current flows between them through a black plastic semiconducting material that also extends the full length of the tape or cable. This heating plastic varies in electrical resistance in response to temperature. It is intended to increase in resistance at warm temperatures so that it draws a very small current and generates very little heat. At temperatures below freezing, however, it should decrease in resistance, draw substantial current, and heat the pipe so that the contents will not freeze.

Self-regulating tapes may be installed in ways that resistance types may not. Because of series resistance characteristics, resistance tapes manufacturers' instructions forbid wrapping one turn over another, because overheating and damage may occur. On the other hand, installation of self-regulating tapes with over-wrapped turns is not expected to cause any problem.

The same difference between the operating characteristics of these tapes permits the use of thicker or more efficient thermal insulation over self-regulating tapes than over resistance tapes. For instance, molded tubular insulation is recommended for use over some self-regulating tapes, but not for resistance tapes.

2. Shielded vs Unshielded

Another important difference among heat tapes and cables is the presence or absence of a metal braid or stranded metal shield. Many shielded tapes are readily identified, because the braided metal shield encloses the entire tape on the outside. Other versions also shield the entire tape or cable, but have an additional insulating jacket covering the shield. Some resistance tape constructions are made with two shields, one covering each of the two active conductors on either side of the tape. In order to be listed by UL or CSA, heat tapes must be shielded.

3. Pre-assembled vs "Do-it-yourself"

Self-regulating heat tapes are available made up to various standard lengths with factory-assembled end seals and power cords. However, for the convenience of users who may want to keep a substantial heat-tape supply on hand to be made up to various lengths as needed, bulk reels of self-regulating cable are marketed, along with end seals and power plugs for field assembly~ Detailed instructions for making up and installing these heat tapes are provided by the manufacturer. Self-regulating heat tapes of this kind will be found with different end-seals And plugs that represent steps in the evolution of this product. Virtually all of the self-regulating heat tapes now being sold employ an end seal which consists of a plastic cap sealed with silicone gel and a plug fitted with a small cartridge fuse similar to an automotive fuse.

C. Installation, Instructions, Installers and Inspectors

1. Improper Installations

While other factors also are involved in causing heat-tape related incidents, improper installation or application were involved in many of the incidents reported in the FY 1991 Pilot study. In spite of clear warnings in the instructions and packaging, pipe-heating tapes were installed in gutters, pipe thermostats were mounted so as to measure ambient air temperature and tubular insulation was installed over tapes intended only for use with glass fiber strip insulation. To determine what can be done to diminish this problem, information is needed to determine when installations were made and the causes for improper installations.

2. Instructions

In situations where a fire incident has occurred, we need to know what instructions were available, if they were read, and if the resulting installation followed the I instructions provided. If the installation was improper how was it improper and what are the indications that something went wrong?

3. Installers

It appears that part of the improper installation problem may be a mis-match between the instructions and the people who are trying to use them. Past investigations how that installation may be performed by mobile-home park maintenance personnel, employees of mobile home

dealers or installation contractors, plumbers, electricians, untrained friends or the resident. Heat-tapes are a relatively complex product. A computer program was used to estimate the educational level required to comprehend typical heat-tape instructions. All of them were estimated at 9th-grade or higher. We need to identify the people who are doing the installing and to try to determine if they have the instructions available, can use the instructions and use other sources of information (Retail sales people, foremen, managers?). A significant factor in some areas may be the installer's native language (Spanish?).

4. Inspectors

To correct improper installations, some municipalities and large mobile-home parks require that the heat-tape installation be inspected before electric power is connected to the home. Particularly in cases where there has been a heat-tape related fire, we need to know if there was an inspection and who the inspector was. It would help to know how he obtained the information to perform the inspection.

It is equally important to find out if the installation was altered significantly after the inspection and what alterations were performed.

D. Operating Environment

1. Grounds, Fuses, and Circuit-breakers

Metal shields and sheaths should be connected to the electrical system earth ground. This connection is provided by the round pin of the three conductor a-c plug and the third-wire grounding conductor of the residential electrical system. When this ground system is complete, it can provide important protection against electrical fires. If some mechanical or overheating injury to the heat tape insulation creates a "short" circuit between "live" conductors of the cable and the shield, the resulting excessive current may cause the branch fuse or circuit to open and atop the current to the heat tape and thus disconnect the energy source that could support ignition.

The same fuse or circuit breaker, usually located back at the residence' electrical service panel, provides some degree of protection against fires that can be caused by a "short" circuit between the two power connections, line or "hot," and neutral. If the current through the line-to-line fault is great enough, the fuse or circuit breaker will disconnect the energy that is driving the ignition source.

To determine the role of the standard 15- or 20-ampere branch circuit protection in preventing heat-tape related fires, we need to know the level of protection (Did someone substitute a 30-ampere fuse?) at the time, whether or not the device opened the circuit, and any other related details. (Was the heat tape plugged into an active power circuit?)

An innovation in heat-tape technology is the provision, in self-regulating heat tapes, of individual fuses for heat tapes integral to the a-c plug body. When these tapes are involved in a fire incident, we need to know the fuse ratings and whether or not the fuses opened.

2. Ground Fault Circuit Interrupters (GFCIs)

Incidents that may have involved a ground-fault-circuit interrupter (GFCI) can provide valuable information about heat tapes, and about mobile homes. Older technology GFCIs may have been overly sensitive to spurious signals. Also, a GFCI located under a mobile home did not provide any alarm in the home, if it tripped. The resident would not be aware that the heat tape was disconnected until a water pipe was frozen. As a result, the federal standard governing mobile-home construction forbids GFCI protection of the heat-tape outlet intended for protection of the water supply pipe.

GFCIs can provide protection at much lower ground-fault current levels than standard branch circuit protection. Incidents where a heat tape was plugged into a GFCI-protected circuit are of special interest in this project.

3. Extension Cords and Receptacle Outlets

UL requires that the label for listed heat tapes warn against the use of an extension cord to connect the tape. There are several reasons for this warning, but the overriding reason is that the use of a flexible cord as a substitute for residential fixed wiring is a violation of the National Electrical Code. In effect, this means that extension cords are only intended for temporary use.

In practice, heat tapes are connected by means of extension cords because the distance from the receptacle outlet to the pipe that is to be protected maybe longer than the power-cord section of the heat tape. The home-owner does not want to pay to rearrange the wiring or plumbing, so an extension cord maybe used as permanent wiring.

Some, usually older-technology, extension cords and receptacle outlets have been involved in heat-tape overheating incidents. Sometimes it is difficult or impossible to determine if overheating commenced in the heat-tape power plug and cable or the extension-cord outlet or the receptacle outlet. Before ignition occurs, both - components involved may have suffered overheating damage. Some extension cords have been subject to overheating of the connections between the wire conductor and the metal connector; some receptacle outlets overheat because of deterioration of the spring-edge contact of back-wired connections or because screw-type terminals were not tightened properly. Also, aluminum wire has been involved in overheating connections.

If the ignition occurred at the plug end of the heat tape, we need information about the extension cord, if one was in use, or the receptacle outlet. When possible, these should be sampled or photographed. It is important to observe the condition of these components whether they did or did not contribute to overheating.

II. INSTRUCTIONS FOR COLLECTING SPECIFIC INFORMATION

A. Summary

Describe the incident, its results, any injuries, the damage, the sequence of events leading to the incident, and the apparent role of the heat-tape or cable in the incident.

B. Specific Objectives

Identify and describe the heat tape, including:

Make, model number, length, power(watts)
Listed, by whom, shielded or unshielded
Resistance type or self-regulating
Pre-assembled or "do-it-yourself"
Materials, construction, condition of end seal and power plug (photo's or sketches)
Labeling and instructions

Describe the environment of the heat tape and its installation including annual use pattern; exposure to weather; means of connecting to 120-V electric power; heat tape wrapped around pipe or fastened parallel to pipe, extent, thickness and over covering of pipe insulation, if present, failures or damage to related equipment, material, etc. Verify that the heat tape was plugged in at the time of the incident.

Describe observable damage to heat tape sustained prior to incident, during incident. Did the damage appear to be related to incident? What are the specific indications of this? was the heat tape buried, immersed, or exposed to salt spray or atmosphere?

When possible, support description with captioned photographs.

Identify the installer of the heat tape and determine what sources of information he used to determine the method and details of installing the heat tape. Try to determine the education, relevant training and experience level of the installer. Determine the date of installation.

If the installation was inspected after completion, determine who performed the inspection, his authority or agency, his education, training and experience. Where did he obtain information about correct method of installation?

Determine the extent of knowledge of the heat tape and installation of the residents of the residence. Were the residents responsible for maintaining the heat tape, or the mobile-home-park manager, the landlord, or someone else?

C. Incident Environment

Indicate the location, single family home, mobile home, beach house, etc.

Try to obtain the fire department report of the incident; interview the fire official who determined the first material ignited to obtain supporting details. Obtain copies of insurance reports or repair invoices.

Indicate apparent deviations from recommended installation procedures, including extension cords (flat or round?, listed?, wire specification on cord?)

Describe the electrical supply to the heat tape, two-conductor outlet?, three conductor outlet? fuse or circuit-breaker rating (amperes). Did heat tape share outlet with other appliances? Did fuse or circuit breaker open the circuit at the time of the incident? GFCI protected? Did GFCI open circuit at time of incident? If not, record manufacturer, age, model number and serial number of GFCI.

Describe the general characteristics of location, including the function, length, size (outer diameter) and material of covered pipe, the location of the thermostat, type of thermal insulation, thickness of insulation.

Did materials other than the heat tape ignite? What are the indications as to how the ignition took place? How did the ignition take place? Were other flammable materials in the vicinity of the heat tape? What were they?

Determine details of use of the heat tape that might bear on its reliability -- annual checkup?, summer shut-down?, use on more than one pipe? use of more than one heater tape on a pipe?, etc.

D. Other

Identify the first material to ignite.

Was the heat tape assembly exposed to water or moisture?; partially buried?

Identify and report the make, etc. of any heat tape that was installed to replace the incident tape.

HEAT TAPE DATA FORM

BACKGROUND:

1. Task number:

2. Date of incident: (year, month, day) ____ ____ ____

3. Time of incident: ____a.m. ____ p.m.

4. Date of investigation: (year, month, day) ____ ____ ____

5. Date heat tape was installed: (year, month, day) ____ ____ ____

6. Type of structure where heat tape was installed:

a) under mobile home ____
b) beside mobile home ____
c) beside built home ____
d) crawl space built home ____
e) basement ____
f) attic/loft ____
g) gutter ____
h) downspout ____
i) plants ____
j) buried ____
k) other ____

7. If a mobile home, give make, model and date of manufacture:

_____

8. In addition to the heat tape, what other materials ignited?

_____

9. Did fire start under a water heater?

a) yes ___ b) no ___ c) don't know ___ d) not available ___

10. Warmest and coldest temperatures in the 24 hours preceding the incident:

warmest _____
coldest _____

PERSONAL AND PROPERTY DAMAGE:

11. Was a victim/s involved in the incident? a) yes ____ b) no ____

12. Victim/s age/s: _____

13. Victim/s sex: a) male/s _____ b) female/s _____

14. Victim/s height/s: _____

15. Did the victim/s have any competency reducing factors?

a) impaired vision ___
b) physical handicaps ___
c) medication ___
d) other ___

16. Nature and type of the victim/s injury/ies:

_____
_____
_____

17. What kind of experience and/or knowledge did the victim/s have of the heat tape?

_____
_____
_____

18. Amount of property damage: _____

HEAT TAPE INFORMATION:

19. Type of heat tape involved:

a) self-regulating, shielded ___
b) self-regulating, no shielded ___
c) resistance, shielded ___
d) resistance, no shield ___
e) don't know ___

20. Heat tape age (months and/or years): _____

21. If a fused plug was used, did it open?

a) yes ___ b) no ___ c) don't know ___ d) not available ___

22. Color of tape: _____

23. Brand name:

a) Easy Heat ___
b) Frostex ___
c) Raychem ___
d) Raychem/Frostex ___
e) Smith-Gates ___
f) Smith-Gates/Easy Heat ___
g) Wrap-On ___
h) Other ___

ATTACHMENT

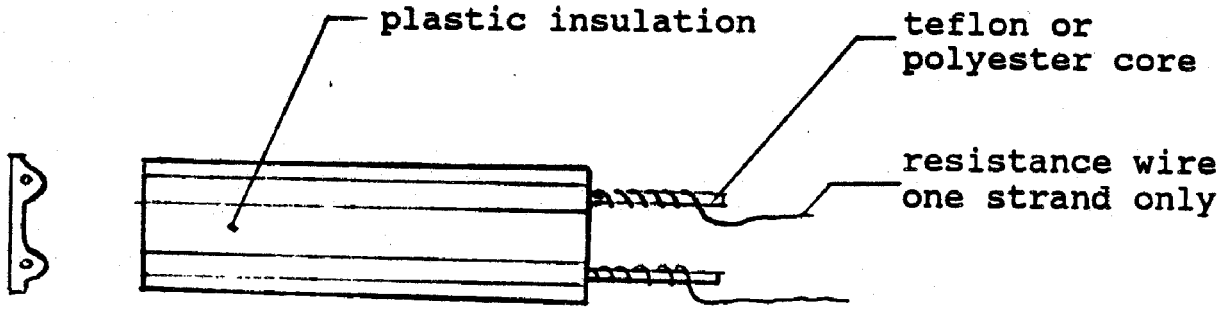

FIGURE 1 TYPICAL RESISTANCE HEAT TAPE (UNSHIELDED)

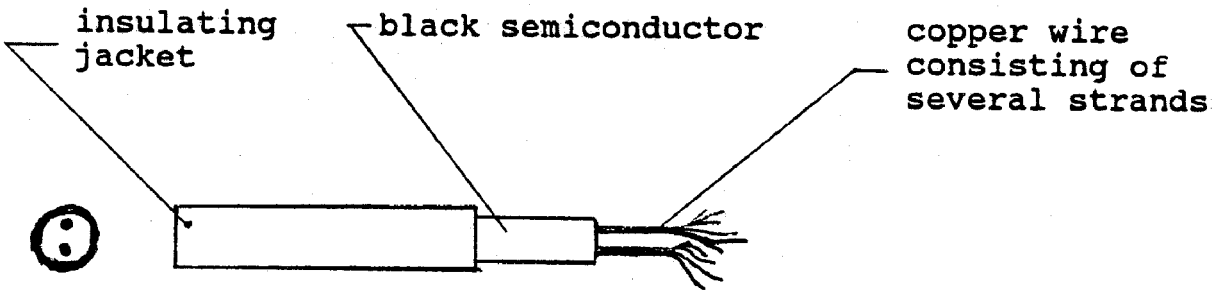

FIGURE 2 TYPICAL SELF-REGULATING HEAT TAPE (UNSHIELDED)